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Application No.	2002/0906
Date of Filing	26 November 2002
Applicant	STOCKERYALE (IRL) LIMITED an Irish company, 4500 Airport Business Park, Kinsale Road, Cork, Ireland

Dated this 3 day of December 2003.

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FORM NO. 1

Application No. 020906

REQUEST FOR THE GRANT OF A PATENT

PATENTS ACT, 1992

The Applicant(s) named herein hereby request(s)

X the grant of a patent under Part II of the Act

______ the grant of a short-term patent under Part III of the Act

on the basis of the information furnished hereunder.

1. Applicant(s)

Name: Stockeryale (Irl) Limited
Address: 4500 Airport Business Park
Kinsale Road
Cork
Ireland

Description/Nationality: An Irish company

2. Title of Invention

"An illuminator and production method"

3. Declaration of Priority on basis of previously filed application(s) for same invention (Sections 25 & 26)

Previous filing date	Country in or for which filed	Filing No.

4. Identification of Inventor(s)
Name(s) of person(s) believed by Applicants(s) to be the inventor(s)

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5. <u>Statement of right to be granted a patent (Section [illegible]7(2) (b)</u>

The Applicant derives the rights to the Invention by virtue of a Deed of Assignment dated 20/11/2002 and an Agreement dated 25/11/2002

6. <u>Items accompanying this Request – tick as appropriate</u>

(i)	X	prescribed filing fee (EUR125.00)
(ii)	X	specification containing a description and claims
	____	specification containing a description only
	X	Drawings referred to in description or claims
(iii)	____	An abstract
(iv)	____	Copy of previous application(s) whose priority is claimed
(v)	____	Translation of previous application whose priority is claimed
(vi)	____	Authorisation of Agent (this may be given at 8 below if this Request is signed by the Applicant (s)

7. <u>Divisional Application (s)</u>

The following information is applicable to the present application which is made under Section 24 –

Earlier Application No: ....

Filing Date: ....

8. <u>Agent</u>

The following is authorised to act as agent in all proceedings connected with the obtaining of a patent to which this request relates and in relation to any patent granted -

<u>Name</u>	<u>Address</u>
John A. O'Brien & Associates	The address recorded for the time being in the Register of Patent Agents, and currently Third Floor, Duncairn House, 14 Carysfort Avenue, Blackrock, Co. Dublin, Ireland.

9. <u>Address for Service (if different from that at 8)</u>

As above

<u>Signed</u> ______________________ JOHN A. O'BRIEN & ASSOCIATES

<u>Date</u> November 26, 2002

"An illuminator and production method"

Introduction

The invention relates to an illuminator and to a method for producing an illuminator.

Light emitting and infrared emitting diodes (referred to hereinafter as "LEDs") are widely used as indicators and as sources of illumination for a wide variety of applications. In order to ensure maximum efficiency, reliable operation, and a long lifetime it is necessary to take various measures in assembling the LEDs into packages or into housings such as are typically used in illuminators.

For the use of single or small numbers of LED dies, the through-pin package (T-Pack) has been developed. In this package the die sits in a metal reflective cavity which enables good optical efficiency by reflecting light from the sides of the chip towards the moulded lens intrinsic to the package. The thermal resistance of the package is acceptable for some applications, but limited by the length of the pins connecting it to the rest of the assembly. This T-pack, and surface-mount variations of it, has become the standard for many applications.

There are also in existence techniques for manufacturing optically efficient arrays by for example using metallized plastic cavities, incorporating optical reflectors, such as are used for scanning sources in photocopying machines. These work well, but are not capable of achieving high LED densities.

For applications such as medical, machine vision, and signage. it is often necessary to try to locate a dense 1 or 2 dimensional array of LEDs close together, and the physical dimensions of T-Packs or surface mount packages limit the densities which can be achieved.

An approach often taken in this case is to work with bare dies, and mount them directly to the circuit substrate such as FR4, making electrical connections from the circuit to the back of the chips with conductive die-attach epoxy or to the front of the chips with wire bonding techniques. In this case a high density (e.g. 4 dies per sq.mm. for normal 0.3mm square dies) of LEDs and correspondingly high brightness can be achieved. If the chips are being operated at high current levels it may be necessary to reduce the thermal resistance of the assembly by using thin ceramic substrate instead of FR4. However, in both of these cases, although there is an improvement in brightness compared with the typically achievable densities with T-Pack or surface mount packages, the improvement is partially offset by a reduction of approximately 50% due to loss of light emitted from the sides of the LED dies, which is not collected by lenses used in these assemblies. Also, the heat which is generated by the density of the LEDs can cause reliability problems and/or reduce useful life.

This invention is therefore directed towards providing an illuminator and production method which enables a good density of LED sources to be achieved in an optically efficient manner, combined with low thermal resistance. Another object is to achieve this using techniques which are compatible with common printed circuit board (PCB) manufacturing techniques, thus enabling cost effective manufacture to be achieved. Another object is to achieve improvements in highly collimated uniform light emission.

Statements of Invention

According to the invention, there is provided a method of producing an illuminator light source circuit, the method comprising the step of:

providing a substrate,

forming a cavity in the substrate, the cavity having the shape of a desired reflector, and

placing a light source in the cavity.

In one embodiment, the substrate is formed to a thermal conductor layer so that the conductor layer forms the base of the cavity and forms a thermal path together with the light source.

In another embodiment, the conductor layer comprises Cu.

In a further embodiment, the cavity has a base and a side wall shaped according to illumination requirements.

In one embodiment, the side wall has a frusto-conical configuration.

In another embodiment, the cavity is coated with a reflective coating.

In a further embodiment, the conductor layer is on an external surface of the substrate, and a heat sink is applied to the conductor layer.

In one embodiment, the heat sink is applied over a high thermal conductivity layer over the conductor layer.

In another embodiment, the heat sink and the high thermal conductivity layer are applied with use of adhesives and pressing.

In a further embodiment, the high thermal conductivity layer is an electrical insulator.

In one embodiment, the high thermal conductivity layer comprises ceramic particles embedden in a resin.

In another embodiment, the ceramic particles are Boron Nitride particles.

In a further embodiment, the cavity is formed by drilling.

Detailed Description of the Invention

The invention will be more clearly understood from the following description of some embodiments thereof, given by way of example only with reference to the accompanying drawings in which:-

Fig. 1 is a diagrammatic cross-sectional side view of a part of an illuminator circuit of the invention.

Referring to Fig. 1 a circuit 1 comprises an LED 2 with a wire bond. The LED 2 is mounted in a cavity having a round shape in plan, a flat circular base 3(a) and a tapered side wall 3(b). The cavity 3 is coated with a reflective coating 4(a), and the LED 2 is secured to the cavity base 3(a) by conductive adhesive 5. The reflective coating 4(a) extends over Cu plating 6(a) around the rim of the cavity 3.

The cavity 3 is formed in a substrate, in this embodiment an FR4 printed circuit board having top Cu plating 6(a) and bottom Cu plating 6(b) on a main FR4 body 7. The process for applying the reflective coating 4 also applies a similar coating, 4(b), to the bottom Cu plating 6(b).

A high thermal conductivity prepreg layer 8 is bonded to the bottom surfaces of the PCB body 7 and platings 6(b) and 4(b). The PCB body 7 has small cavities or wells 10 in its bottom surface to accommodate excess adhesive when the layer 8 is being

bonded. Such wells may be avoided if the copper 6(b) pattern on the underside of the body 7 is such as to provide the same effect. A heat sink 9 is subsequently bonded to the layer 8 underneath the LED 2 by thermally conductive epoxy.

The process for producing the circuit of Fig. 1 is as follows. These steps are performed for each of a large number of LEDs 2 to be mounted in an array on a single board.

(a) The PCB comprising the body 7 and the plating 6(a) and 6(b) is provided. This is drilled with a profiled, in this case a tapered drill bit conforming to the shape of the cavity 3. A lubrication is used to provide a smooth finish. Drilling is continued through the full depth of the body 7 until the drill bit exposes the lower Cu plating 6(b).

(b) The base 3(a) and the tapered side wall 3(b) of the cavity 3 are then coated using known steps for plating through holes in PCBs. In this embodiment, the plating sequence is 20-40 microns of matt Cu, a thin layer of bright Cu, 2-5 microns of bright nickel, and a sub-micron layer of gold. Other alternative reflective coatings will be known by those skilled in the art.

(c) The plating 6(a) and 6(b) is then etched to form the desired circuit patterns for connectivity of the LEDs 2 and other components.

(d) The layer 8 and the heat sink 9 are then applied using adhesives and a pressing operation performed with insertion of a support in the cavity 3. A support may alternatively be avoided if plating thickness and geometry provide sufficient strength for pressing. An important aspect of the layer 8 is that it has high thermal conductivity for dissipation of heat to the heat sink 9. The layer 8 comprises a prepreg resin with embedded Boron Nitride particles at a concentration in excess of 30% to achieve thermal conductivity. The thermal

conductivity is of the order of 120-140 W/m °C. In other embodiments, different ceramic particles may be used.

(e) Finally, the LED 3 is placed on the base 3(a) with a thermally conductive adhesive 5.

It will be appreciated that the invention achieves use of a standard PCB to provide reflective, heat dissipation, and connectivity requirements of an LED array in a simple and compact manner. The configuration of the cavity 3 can be chosen in a versatile manner to suit the particular application. The bonding and pressing operations achieve excellent physical strength together with the desired heat dissipation to the heat sink 9. The adhesive 5, the reflective (metal) coating 4(a), the base Cu copper 6(b), the coating 4(b), and the layer 8 provide excellent thermal conductivity to the heat sink 9. Indeed, it is envisaged that a heat sink may be simply glued on with electrically insulating glue or dispensed of for some configurations and/or light sources.

The invention is not limited to the embodiments described but may be varied in construction and detail. For example the PCB may be multi-layer, incorporating plating internally, and possibly also incorporating a layer such as the layer 8. Also, the substrate may be of any suitable material other than FR4, such as ceramic, plastics, metallized plastics, or high temperature epoxy. An important criterion is that the material is of a type which can be drilled to expose a smooth surface which can accept a reflector layer. In general, non-PCB technology may be used including moulding or machining steps in different materials. There may be vacuum deposition of parts. The layer underneath the light source may be of a different material having a high thermal conductivity. The cavity may be formed in ceramic or metal, in which case there may be no need for a reflective coating. Also, the cavity may be filled or partially filled with phosphorescent material, such as for producing white light from a blue source. It is also envisaged that a lens may be

mounted within the field of emission of the LED, possibly using an over-moulding process. The cavity may have a different shape such as frusto-pyrmadial, parabolic, elliptical, or hyperbolic as examples. The shape is in general chosen for optimum reflectivity. Also, high thermal conductivity particles other than ceramics may be used.

Claims

1. A method of producing an illuminator light source circuit, the method comprising the step of:

providing a substrate,

forming a cavity in the substrate, the cavity having the shape of a desired reflector, and

placing a light source in the cavity.

2. A method as claimed in claim 1, wherein the substrate is formed to a thermal conductor layer so that the conductor layer forms the base of the cavity and forms a thermal path together with the light source.

3. A method as claimed in claim 2, wherein the conductor layer comprises Cu.

4. A method as claimed in any preceding claim, wherein the cavity has a base and a side wall shaped according to illumination requirements.

5. A method as claimed in any preceding claim, wherein the side wall has a frusto-conical configuration.

6. A method as claimed in any preceding claim, wherein the cavity is coated with a reflective coating.

7. A method as claimed in any preceding claim, wherein the conductor layer is on an external surface of the substrate, and a heat sink is applied to the conductor layer.

8. A method as claimed in claim 7, wherein the heat sink is applied over a high thermal conductivity layer over the conductor layer.

9. A method as claimed in any of claims 7 or 8, wherein the heat sink and the high thermal conductivity layer are applied with use of adhesives and pressing.

10. A method as claimed in any of claims 8 to 9, wherein the high thermal conductivity layer is an electrical insulator.

11. A method as claimed in claim 10, wherein the high thermal conductivity layer comprises ceramic particles embedden in a resin.

12. A method as claimed in claim 11, wherein the ceramic particles are Boron Nitride particles.

13. A method as claimed in any preceding claim, wherein the cavity is formed by drilling.

14. A method of producing an illuminator light source circuit substantially as described with reference to the drawings.

15. An illuminator light source circuit whenever produced by a method as claimed in any preceding claim.

16. An illuminator comprising a light source circuit of claim 15.

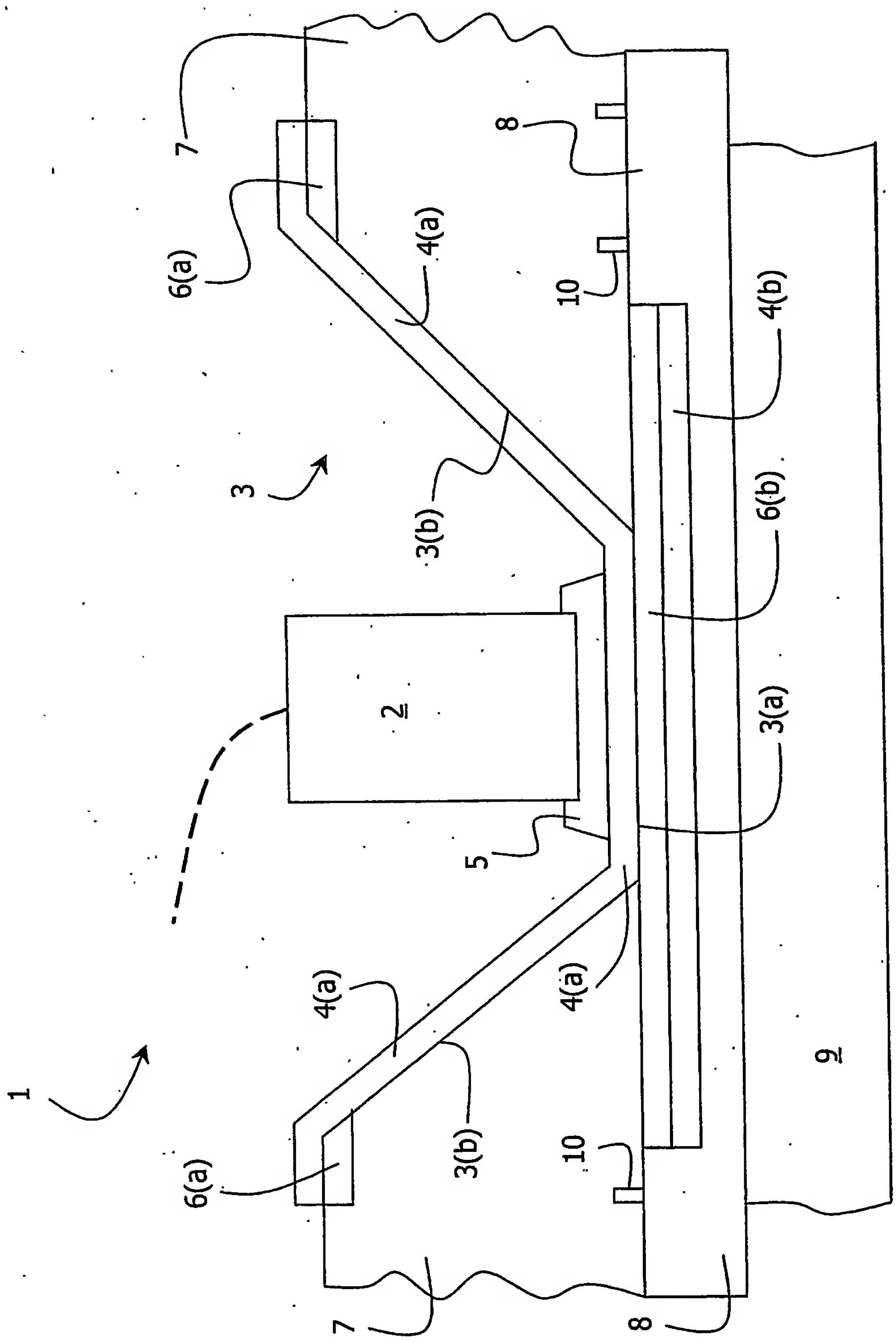

Fig. 1